

Workshop on Coherent Synchrotron Radiation in Storage Rings



Workshop attendees pose for the traditional group photo at the conference hotel in the Napa Valley wine country.

Recently, there has been much excitement about the possibility of broadband coherent synchrotron radiation (CSR) as a source of intense radiation in the traditionally difficult far-infrared/terahertz wavelength region. One of the most interesting features of CSR is that the emitted power scales quadratically with the number of electrons involved. Since the typical number of electrons in a bunch is a billion or more, the potential for gain is huge. To discuss recent advances in exploiting this novel source, the Workshop on Coherent Synchrotron Radiation in Storage Rings was held in Napa, California, on October 28–29, 2002. The workshop was sponsored by the Advanced Light Source (ALS) and BESSY-II and was chaired by John Byrd (ALS).

The possibility of generating broadband CSR was raised over half a century ago with the

advent of the first high-energy electron accelerators. Coherent emission occurs when the length of the electron bunch (or any structure on the bunch) is comparable to the wavelength of the emitted radiation. The longest emitted wavelength is limited by a waveguide cutoff condition determined by the vacuum chamber height and the radiation opening angle and typically is between a few millimeters and few hundred microns in third generation rings. Therefore, bunch lengths less than a few millimeters and vacuum chambers large enough to transmit the radiation are necessary for observing CSR.

The first observations of stable CSR in a storage ring, reported at the workshop in presentations by Gode Wustefeld (BESSY-II) and by Peter Kuske (BESSY-II), were achieved via reduction of the bunch length at low currents (~ 10 $\mu\text{A}/\text{bunch}$) by reducing the lattice mo-

mentum compaction and controlling higher order effects with harmonic sextupoles. The BESSY group observed a coherent enhancement at wavelengths as short as a few hundred microns. Fernando Sannibale (ALS) showed that the emission at shorter wavelengths than expected can be explained by a static distortion of the electron bunch due to its interaction with the radiation.

However, the gain from the CSR is not unlimited. The interaction of the radiation with the electron beam can also drive a self-amplified instability, resulting in periodic bursts of CSR. Such bursts of far IR synchrotron radiation have been observed at a number of rings. A model of this instability was presented by Gennady Stupakov (Stanford Linear Accelerator Center) and the first experimental results showing agreement of the instability threshold

with this model were shown by Byrd. Marco Venturini (SLAC) presented simulation results that exhibited the transition from stable CSR to an unstable bursting regime.

Michael Martin (ALS) presented the scientific motivation for a bright source of radiation in the far-infrared/terahertz wavelength range. The energy scale of terahertz photons well matches that of many low-energy (meV) phenomena in condensed-matter physics and strongly correlated systems in particular. The high intensities from an optimized CSR source could also open up new non-linear effects in which low-energy electronic transitions and/or phonons can be directly pumped. Finally, the use of novel measurement techniques such as electro-optic sampling and broad-band electron spin resonance in high-fields could couple powerful analysis tools to this new powerful photon source. Heinz-Wilhelm Hubers (Ger-

man Aerospace Corporation) demonstrated the advantages of collaborating outside one's immediate field by presenting the latest developments in airborne infrared and millimeter-wave detectors, several of which were used to measure the CSR at BESSY-II.

There were several ideas presented for a new dedicated source of CSR. At the ALS, there is an actively researched proposal for a small ring with an energy of about 700 MeV that could produce picosecond bunches and a total coherent power of some watts. This ring would be built on the shielding of the ALS booster synchrotron. One of the interesting features of such a ring is that little floor space is needed for the beamlines as compared to a typical X-ray synchrotron source. Vladimir Litvenenko (Duke University) presented a variation on this idea in which a millimeter-wave free electron laser (FEL) is used to mi-

crobunch the electron bunch, resulting in a kilowatt of coherent power. An energy recovery linac (ERL) is another option that can produce short bunches. Michael Martin (ALS) presented the results of measurements of a world record 20 Watts of coherent power at the Jefferson National Accelerator Laboratory FEL, which is based on an ERL.

In sum, the workshop proceedings demonstrated that the accelerator community is well on the way to understanding the coherent emission process and, potentially, producing a bright new source in the far-infrared. The workshop agenda and vu-graphs of the presentations can be seen at www-als.lbl.gov/LSWorkshop/. ■

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